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(54) Title of the Invention: Device For Generation of High-Output CO_2 Laser With Wavelength-Selective Internal Modulation And Optical Pulses

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Specifications

1. Title of the Patent: Device For Generation of High-Output CO_2 Laser With Wavelength-Selective Internal Modulation And Optical Pulses

2. Scope of the Patent's Claims

1. A device for generation of optical pulses with wavelength-selective internal modulation and optical pulses of a high-output CO_2 laser, characterized by the fact that a specific laser

resonator is equipped with a first resonance mirror (3) having a determined reflectance R_1, frequency selection element (2), a specific discharge tube (1) enabling excellent angle selectivity with East German economic specification number H01S/19976, as material for transmission of laser light rays;

creating a construction comprising specific structural elements forming a modulator having a high limiting frequency as well as a second resonance mirror having variable resonance R_2;

with a construction of a Fabry-Pérot interferometer (4) having an optical path length which can be promptly modulated with the modulator;

enabling to change reflectance R_2 from zero to the maximum value with a control signal corresponding to the length of the optical path;

wherein since each value of R_2 is a function of the laser wavelength, the result is that this makes it possible to conduct operations with a predetermined wavelength with an angle-selective element and laser frequency;

enabling either a constant adjustment so as to achieve the maximum wavelength selected for continuous output of CO_2 laser per the total resonance loss with the Fabry-Pérot interferometer (4), or to promptly modulate within a wide range of modulation and at a high speed and with a large modulation extent the strength of the generated laser light rays, or to change with a sufficient speed the total resonance loss during a status transition from a laser value below the operating threshold value to the complete laser function;

providing a device for generation of optical pulses with a wavelength-selective internal modulation and optical pulses of a high-output CO_2 laser having an excellent output gradient of the generated laser pulses.

2. The device for generation of optical pulses with wavelength-selective internal modulation and optical pulses of a high-output CO_2 laser described in claim 1, characterized by the fact that one part of the operating light rays (8) is supplied promptly via optical splitter (7) to a light ray detector (10);

[page 2]

wherein the measurement signal in electronic device (11) is processed so as to be used for modulation enabling to guarantee the target value of the laser output set in advance for reflectance R_2 via feeding current device (5) of a specific interferometer with a modulation value created by comparing the target value to the real value.

3. Detailed Explanation of the Invention

(Sphere of Industrial Use)

This invention relates to a device for generation of optical pulses with a wavelength-selective internal modulation and optical pulses of a high-output CO_2 laser which can be used to achieve tasks requiring specific optical parameters such as optical pumping of infrared laser rays or isotope separation achieved with laser light by using preferably stamping and surface processing of the area in the vicinity of regions processed by stamping, applied to glass and wood processing, processing using electrons or microwaves, welding and hardening, and cutting of metallic materials with a device for generation of optical pulses using a selective internal modulation of high-output CO_2 laser wavelengths.

(Prior Art Technology)

To make it possible to use a high-output CO_2 laser directly in a laser oscillation device, the functions that can be used with laser technology to enable strength regulation and generation of optical pulses must be greatly improved. These conditions are absolutely required to enable the use for the above mentioned purpose. A particular function required in order to enable regulation and generation of optical pulses is the so called pinnacle output of pulses with special parameters which can be freely selected, and also the capability to control from an external part the frequency of the pulse sequence including an asynchronous pulse sequence and a continuous pulse period. A simultaneous wavelength selection is thus very desirable.

A high-pressure gas laser (TEA-laser) can be used with the horizontal mode to generate pinnacle output of high pulses in a terminal used for high-pressure output of laser gas to make it possible to generate oscillations with optical pulses of a laser gas. Obviously, when this principle is used, the problem is how to generate a continuous frequency of high pulses. Accordingly, a very costly technology is required to generate a frequency with several hundred Hz.

Another method is the Q-switch method which can be used with laser resonators to generate a sloping pinnacle output of pulses per output during continuous operations. However, the problem with modifications of this method realized according to prior art is that basically none of them is suitable in the range of applications using laser.

As explained by Furain [transliteration of a foreign name into Japanese] et al., (IEE Journal of Quantum Electronics, QE-2, page 378 (1966), the Q-switch method is particularly suitable for processing of materials using rotating mirrors and the gas laser pulse generating method.

However, due to a significant loss of the mean radiation output when the time factor is taken into consideration, this method is not suitable for laser processing. A suitable pulse sequence has also not been obtained.

A passive Q-switching method for CO_2 laser using a gas with specific absorptive characteristics which is deployed in a resonator is disclosed in Applied Physics Letters, 11, page 88 (1967). The disadvantage of this method is that a specific continuous pulse frequency of several Hz is set due to the use of a gas which is dependant on the components of the gas mixture and also the mean laser output that can be switched in another direction is limited.

A very effective method in the visible spectrum range which can be obtained as a result of photoelectric changes in crystals with a wavelength in the infrared range, on average 10 μm, can be realized only with high expenses.

Because this method is used with large and long crystals, it also has a relatively high absorption loss, it is costly, and also a costly voltage control is required for a sufficient modulation (for instance as described in IEEE Journal of Quantum Electronics, QE-2, page 378, 1966).

The strength of the laser can be controlled with a specific transmittance interferometer in the location of mirrors having a partial transmittance. A similar arrangement is described in West German Patent Disclosure Number 2223945 and also in West German Patent Disclosure Number 2044280. Both publications propose a magneto-optical method or a magneto-optical effect with a specific interferometer. According to both constructions, CO_2 laser is used as a typical item first with the visible spectrum range, and secondly with a relatively low median output.

According to another method, the efficiency of diffraction is limited to Bragg diffraction with a grating generating an acoustical and optical phase.

[page 3]

Bragg diffraction thus results in a relatively small modulation which is not suitable for processing of materials with CO_2 laser. There is also a possibility that modulation of discharge currents during laser gas discharge can be used with advantage for technological purposes. However, this mechanism in principle limits the maximum possible achieved modulation frequency for a sufficient regulation as required. Because this limiting frequency is with gas lasers 2.5 kHz, a large loss of the laser output will be generated in this case with the frequency of up to 1 kHz. In addition, the electrical mechanism of the gas discharge is limited to about 10 times the amount of the gradient that can be achieved with the pinnacle output of the pulse, involving a time consuming transition process due to the processes creating the mechanism of reversed distribution of the gas discharge and threshold value of the laser.

West German Patent Disclosure Number 2816659 proposes a construction increasing the limiting frequency. The gas laser has at least two gas discharge tubes connected in parallel to a gas laser, enabling pumping with electric current pulses corresponding to a specified time interval applied to the gas discharge tubes. Although this makes it possible to increase the limiting frequency by the pumping mechanism of the gas laser, it goes without saying that the

energy of individual optical pulses is decreased in accordance with the increased frequency.

(Purpose of the Invention)

The purpose of this invention is to provide the construction of a device which can be used to generate optical pulses and selective internal modulation of laser wavelengths to enable a highly effective processing design with a precise process and specified optical parameters as well as optimal operating conditions during high-speed processing of substances (including of course also sharpness), such as metals having a specific hardness, profiles of highly reflective materials (aluminum) and other materials processed by stamping, or surface treatment, removal processing, according to specifications of highly processed materials having a specified hardness, processing of materials having a high reflectance (aluminum), electro-processing, microwave, optical or writing systems, etc.

(Concrete Task of the Invention)

The task of this invention is to provide the construction of a device that can be used to generate optical pulses and a wavelength-selective internal modulation of high-output CO_2 laser having an external controlling part, linked clearly to the parameters of pulse generation and electric modulation of laser gas discharges which can be utilized advantageously with conventional devices. The invention is also compatible with a perfect flexibility of the emission parameters in accordance with the task to be solved, in addition to the optical conversion of the mean laser output utilized in this manner. The construction of this invention guarantees oscillations which can be obtained with a high pulse sequence frequency in high kHz enabling at the same selection of wavelength required in the infrared range having characteristics enable to generate with high precision and with a specified sequence of pulses according to the very precise pulse generation construction of this invention.

(Solution Means)

This task is solved by a novel construction which is used for a fast Q-switch of a high-output CO_2 laser.

(Effect of the Invention)

Thanks to this construction, firstly, free selectivity is enabled with a frequency selecting element deployed inside a resonator. Secondly, because a specific gas discharge tube corresponding to economic specification OIS/No. 199976 is used, this makes it possible to use an essentially flat, single color wavelength region for the laser output achieved so that fluctuations of reflectance on the tube walls can be avoided with a device using TEM 00-operations selected to correspond to the radius of curvature of the resonance mirror with a specified fixed resonance R_1, according to the characteristics of the resonator corresponding to the laser. The characteristics of this invention thus make it possible to eliminate the disadvantages of conventional methods

for Q-switches, in particular, they enable adjustments making it possible to avoid absorption in resonators provided with passive Q-switches and also time adjustments of the resonator construction with a switch resulting in a considerable loss of the mean laser output.

Secondly, because the resonance mirror per se is formed with a well known type of the Fabry-Pérot interferometer, this interferometer can be formed from plates using 2 transparent materials, in particular GE, GaAs, or ZnSe. These plates can be deployed opposite each other or in parallel, creating a smooth construction enabling resonation with surfaces for laser wavelengths having desired dimensions, while there will be no resonance on the opposite side. Because the length of the optical path between both surface of the interferometer, which is determined by n . d (d is the distance between both surfaces of the interferometer and n is the index of refraction in the space of the medium), is relatively small, the order of the minimum laser wavelength is at the most about 1 mm.

[page 4]

Because the frequency selective element and angle selective gas discharge tube create excellent interference characteristics for a flat, single-color wavelength region, this enables modifications in a wide range between the maximum value Rmax applied by the reflectance between both interferometer surfaces and minimum value Rmin = 0 of effective reflectance R_2 of the interferometer with optical path n . d. This means that with a small absorption rate, the transmittance of the system can be changed from Tmax = 1 to Tmin = 1 - Rmax.

The construction of this invention makes it possible to modulate the length of the optical path between the plates of the interferometer having as high a limiting frequency as possible (many kHz) with a control signal which corresponds to the particular structural elements. In this case, when R_2 is changed within a specified wide range, the strength of the laser rays generated along with the total loss of resonance will have an influence enabling modulation with a high speed and with a high degree of modulation. This makes it possible to obtain optical pulses having a spectacularly high output with the method of this invention when a sufficiently speedy modulation is applied per the total loss of the resonator during transition from a status when the laser value is below the operational threshold value (this state generally corresponds to a relatively small R_2) to a complete laser status (this state generally corresponds to a relatively large R_2 value).

When the device of the high-output CO_2 laser for generation of optical pulses and selective internal modulation of laser wavelengths is operated with cw operations, this makes it possible to operate the device with a novel method enabling a prompt output as well as stability. Because of that, the measurement signal, supplied via a light ray splitter promptly through a light ray operating part to an optical detector as measurement signal, can be amplified with an electron device and compared to the target value. A composite value creating the modulation value according to this invention based on the difference between the target value and the real value can then be used for modulation in order to guarantee a specified target value of laser output with

a specific variable reflectance R_2 of the interferometer construction. In this case, the output of the laser is a function of the total loss of the resonator corresponding to the function of R_2. The time constant according to this formula can be thus used to set the detector, electron modulator, and interferometer with this time constant, resulting in $\tau = 100\ \mu s$. This provides a wide coverage for normal modulation based on changes of the gas discharge current.

(Embodiment)

An embodiment of this invention will now be explained.

Figure 1 shows a device used to generate light pulses and wavelength-selective internal modulations of high-output CO2 laser. Specific gas discharge tube 12 corresponding to economic specifications 01S/19976 and oscillation selection element 2 are used with specified TEMOO operations and a corresponding resonance mirror having a fixed reflectance R_1, as well as a corresponding inner diameter of gas discharge tube 1 of a laser resonator. Also, a single-color wavelength region can be used with a required surface area instead of a specific interferometer.

A specific interferometer construction is formed with a modulator using economic specifications 01S/2640056. The modulation of the output of laser rays is achieved with electric signal enabling modulation with feeding current device 5 with the method shown in the figure along with the modulation of transmittance R_2 of the modulator. The electric current is supplied for gas discharge via electric current supplying device 6. High-output CO_2 laser can thus be operated with cw operation with prompt and stable target laser output via light ray splitter 7, in particular a prism lens corresponding to economic specifications 01S/204920, so that a part of the operating light rays can be supplied promptly to optical detector 10. The measurement signal is processed by electron device 11, and modulation value 12, obtained by comparing the target value to the real value, is then used for modulation in order to guarantee the target value of the laser output with variable transmittance R_2 via feeding current device 5 of specific interferometer 4.

4. Brief Explanation of Figures

Figure 1 indicates a device used to generate light pulses and wavelength-selective internal modulations of high-output CO2 laser for processing of material.

Explanation of Codes

1 ... discharge tube for a specific gas,
2 ... frequency selection element,
3 ... resonance mirror,
4 ... Fabry-Pérot interferometer.

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[page 5]

Figure 1

Continuation from page 1:

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